2003 Fuel Cell Seminar, November 2-7
Miami Beach, Florida, USA

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Superior MicroPowders

Combinatorial Spray-Based Synthesis of PEM FC Electrocatalysts

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Cabot Superior MicroPowders, USA

Content

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Superior MicroPowders

- **Superior MicroPowders Now a Division of Cabot Corporation**
- **CSMP Powder Production Process**
- **Combinatorial Spray-Based Synthesis of Binary and Ternary Alloys**
- **Conclusions and Path Forward**

Cabot is a Global Company

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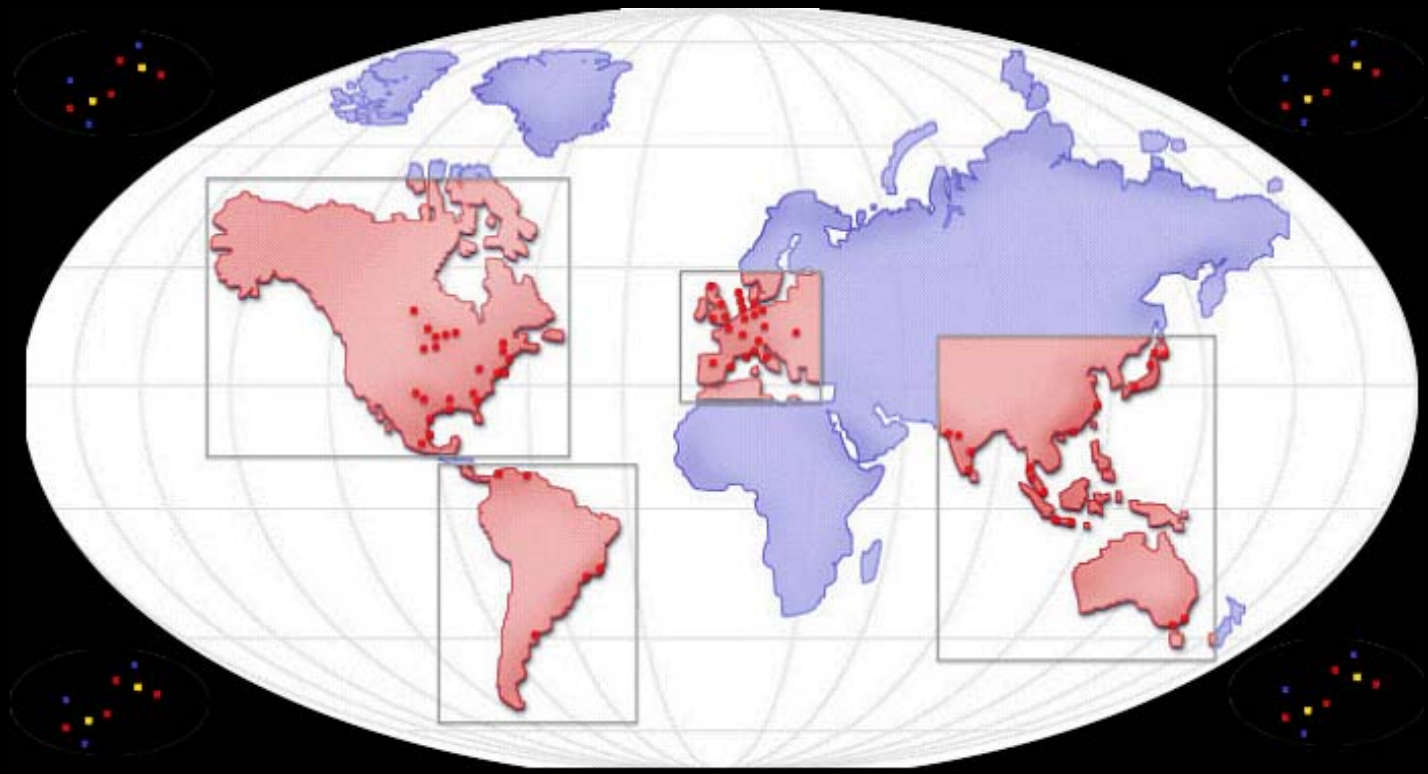

4,200 employees in 27 countries and 40 sites

Cabot Businesses

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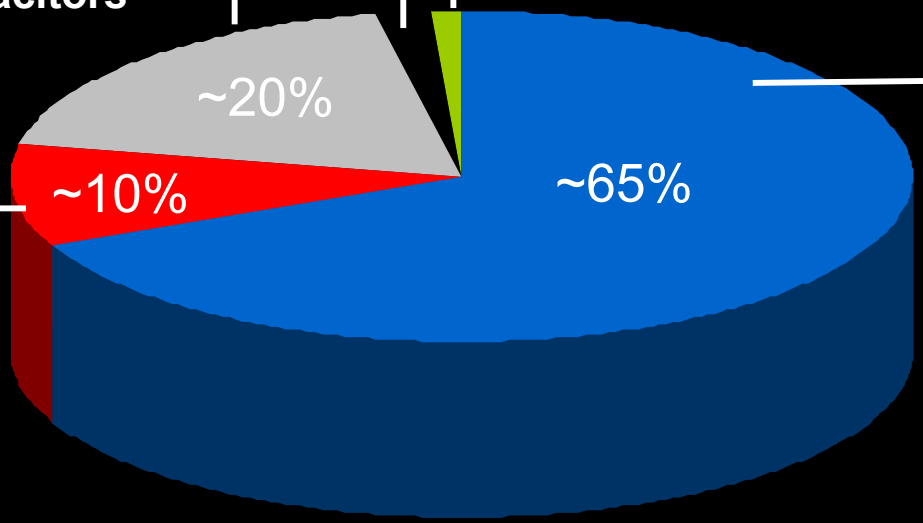
Specialty Oil Field Fluids - ~2%

Inkjet Colorants - ~1%

Performance Materials
- Electronic capacitors
- Metals



Carbon Black
- Tires
- Hoses
- Belts
- Inks
- Paints
- Coatings
- Cable
- Pipe
- Fibers

Fumed Metal Oxides
- Silicone Rubber
- Raw materials for CMC
- Coatings, Toners, and Inks

Total Sales in 2002 = $1.6 billion

Process Components

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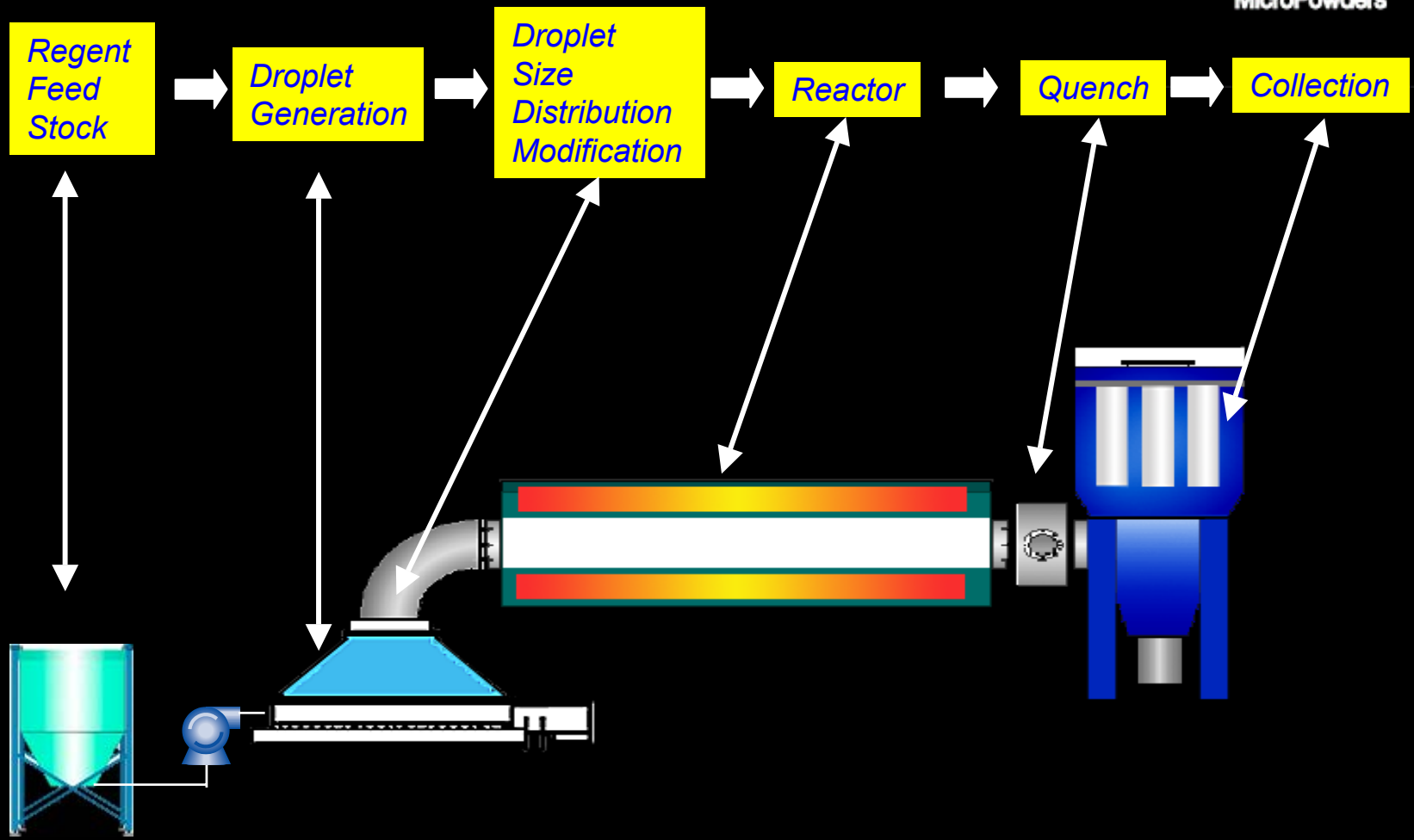

Process Simplicity
~ Feedstock Droplet ~

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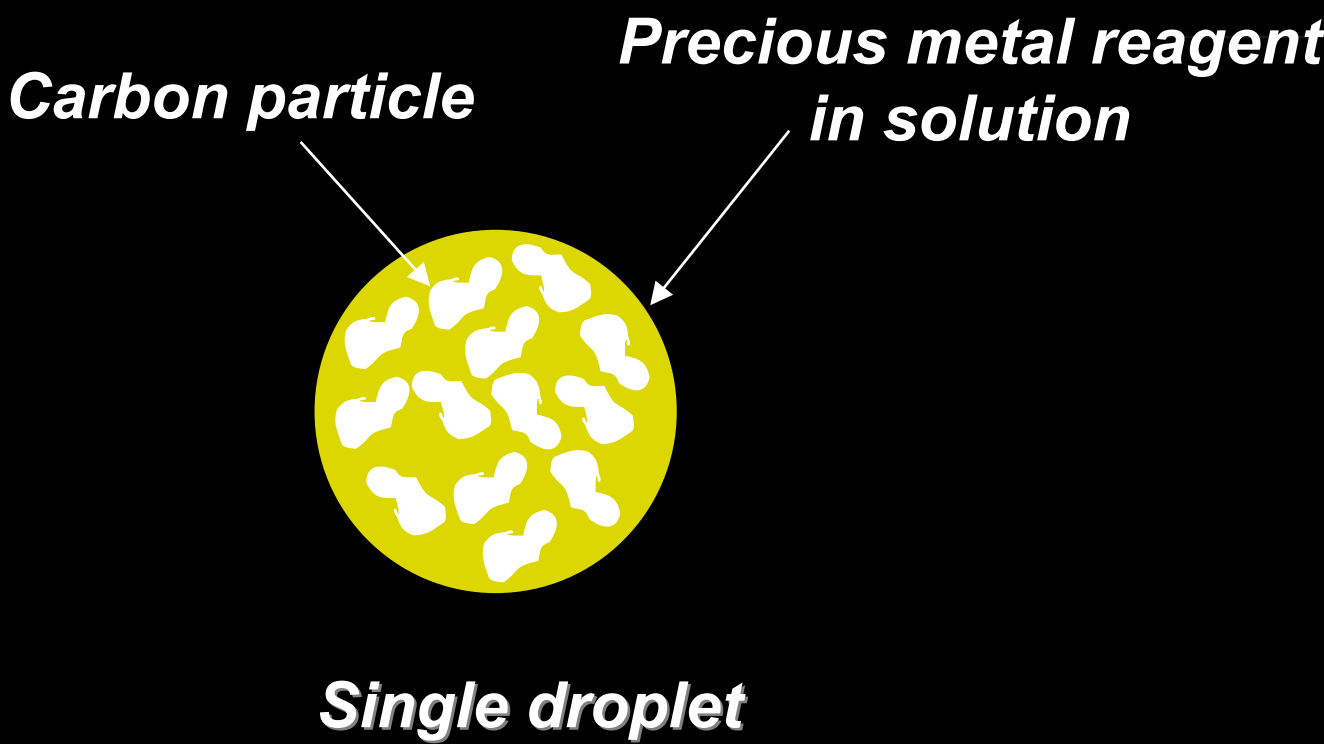

Process Operation

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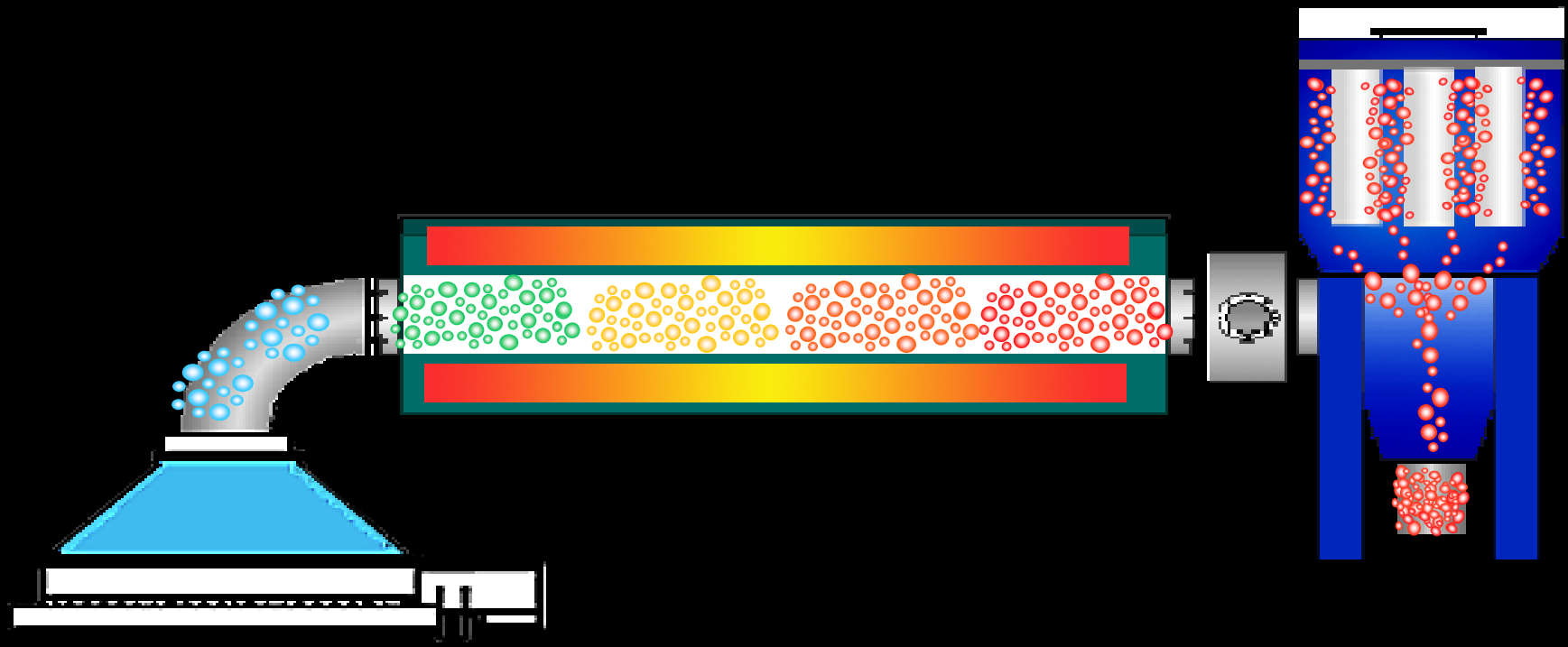

Final Product

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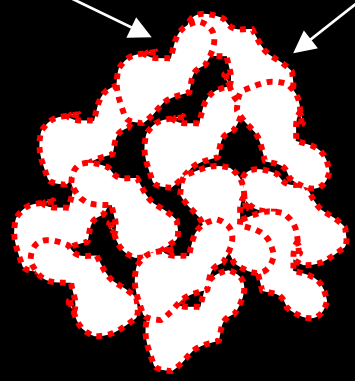
Precious metal nanoparticle

Carbon nanoparticle



Electrocatalyst aggregate

CSMP Electrocatalyst Powders

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- Standard ***Dynalyst***^{TM} Electrocatalysts

Cathode		Anode	Carbon Supports
10% Pt/C	20% Pt/C	40% PtRu/C	Shawinigan black
30% Pt/C	40% Pt/C	60% PtRu/C	Vulcan® XC-72
50% Pt/C	60% Pt/C		Ketjen black
MnO_x/C			

Development of High-Performance, Low-Pt Cathodes Containing New Catalysts and Layer Structure

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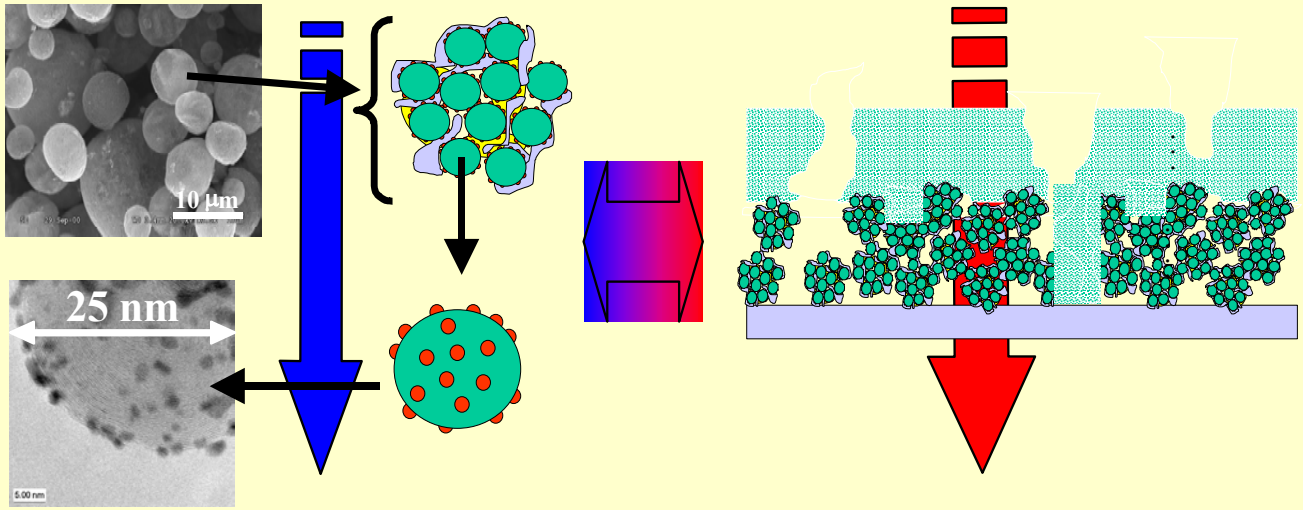
Effort 1

Discovery of new, low Pt catalyst compositions and particle microstructures

Effort 2

Modeling and deposition of engineered cathode layers



High Performance Low-Cost MEA

- **Effort 1:**
  - *CSMP*
  - *DuPont Fuel Cells*
- **Effort 2:**
  - *CSMP*
  - *CFDRC*
- **Short Stack Testing:**
  - *GM*
  - *Partnerships*

Combinatorial Discovery of New Compositions & Microstructures

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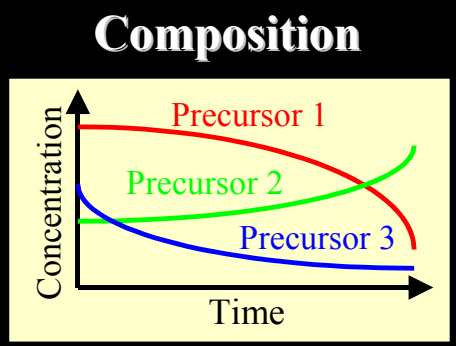
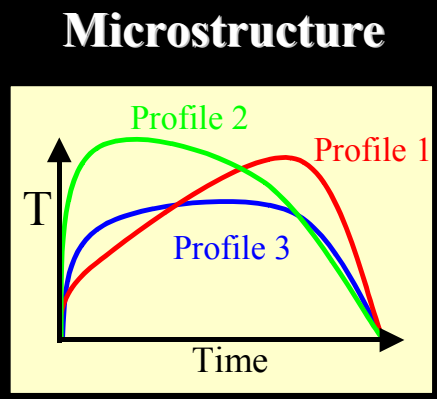
- Compositional variability
- Microstructural variability
- Discovery on commercially scaled platform





Selection of Composition and Structure Targets

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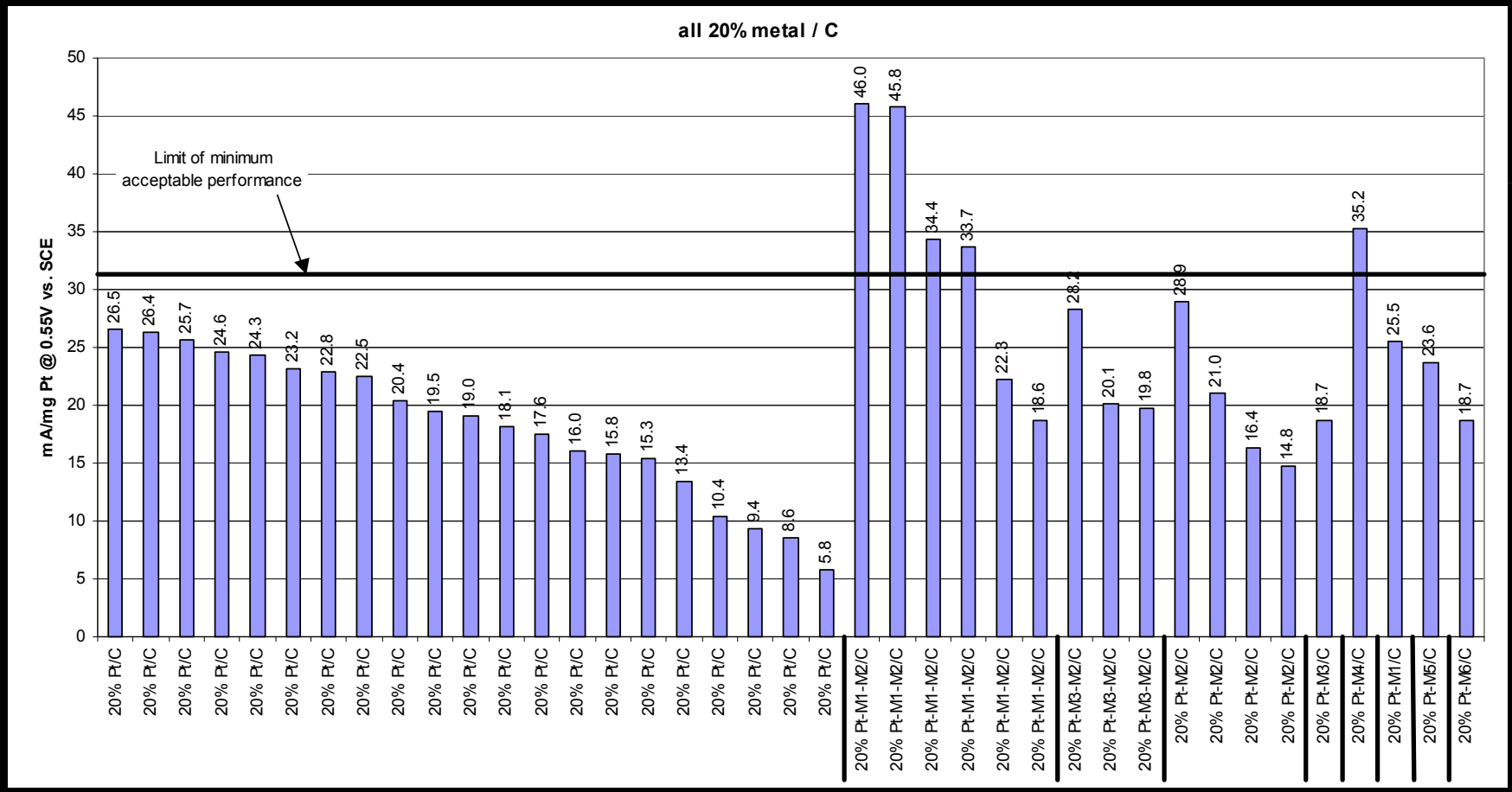
- ***Cost of components*** - raw materials, precursor cost
- ***Cost of manufacturing*** (precursors, processing steps) - fabrication cost
- ***Demonstrated performance advantage*** or possible one based on established general trends
- ***Long term stability***
  - stable in acidic media/resistant to corrosion
  - sustainable performance at high potentials
  - sustainable dispersion of the active phase

High Throughput Screening Data for CSMP Electrocatalysts



DuPont Fuel Cells

"... powered by DuPont"

High Throughput Data – Performance Maps of Alloys

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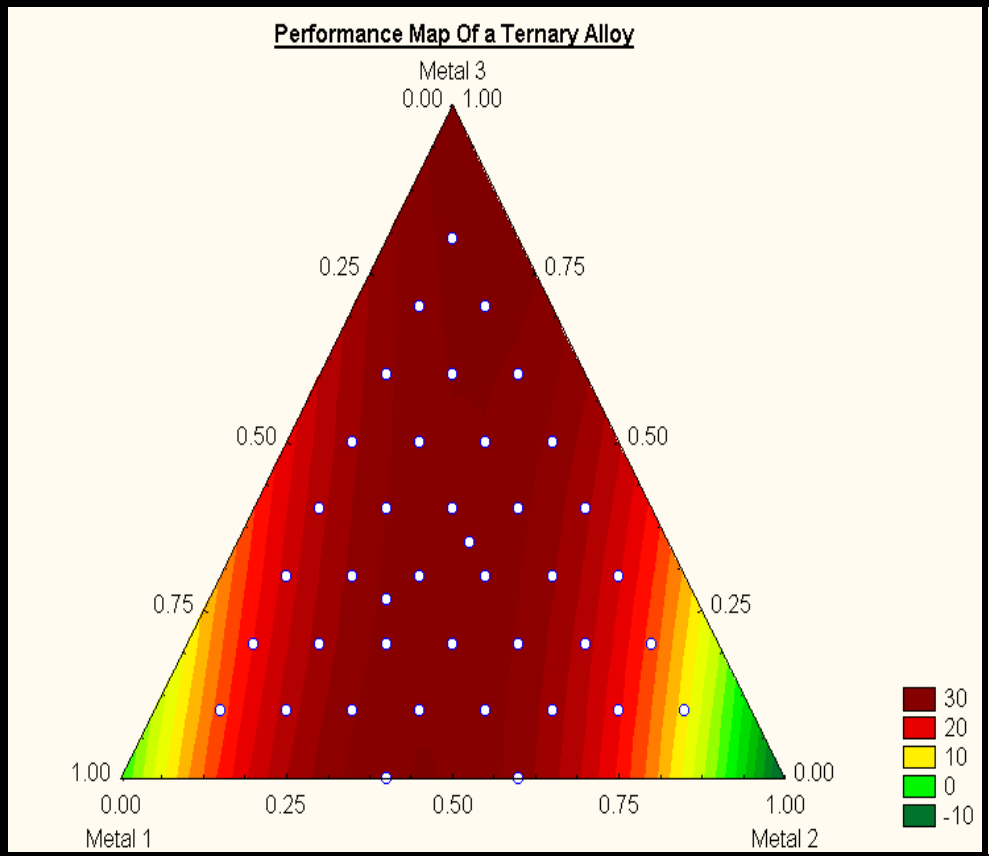
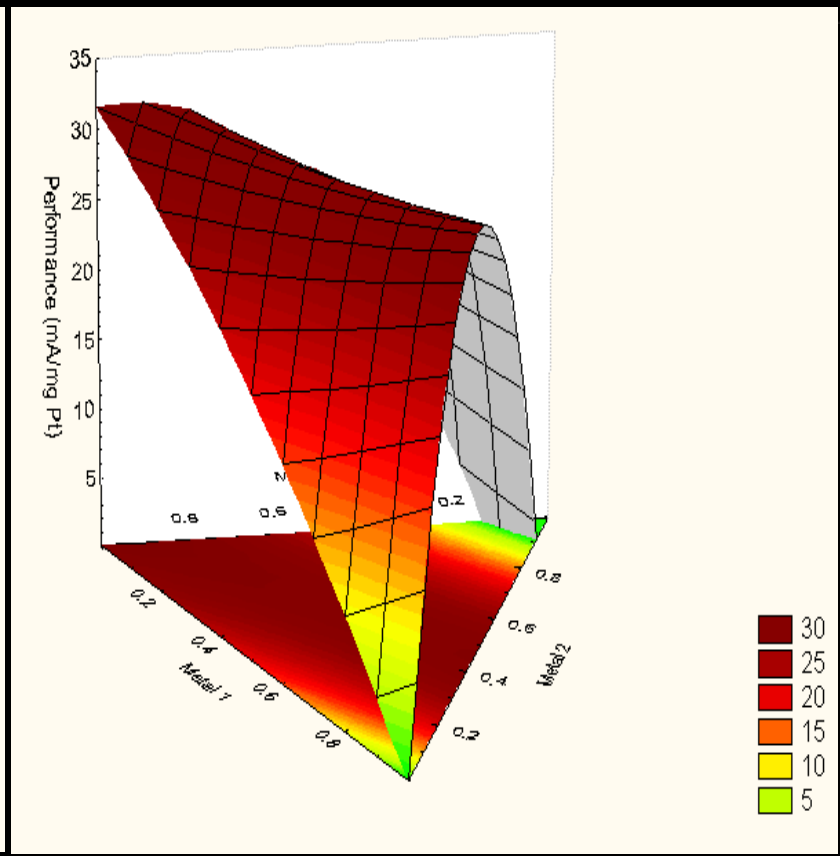
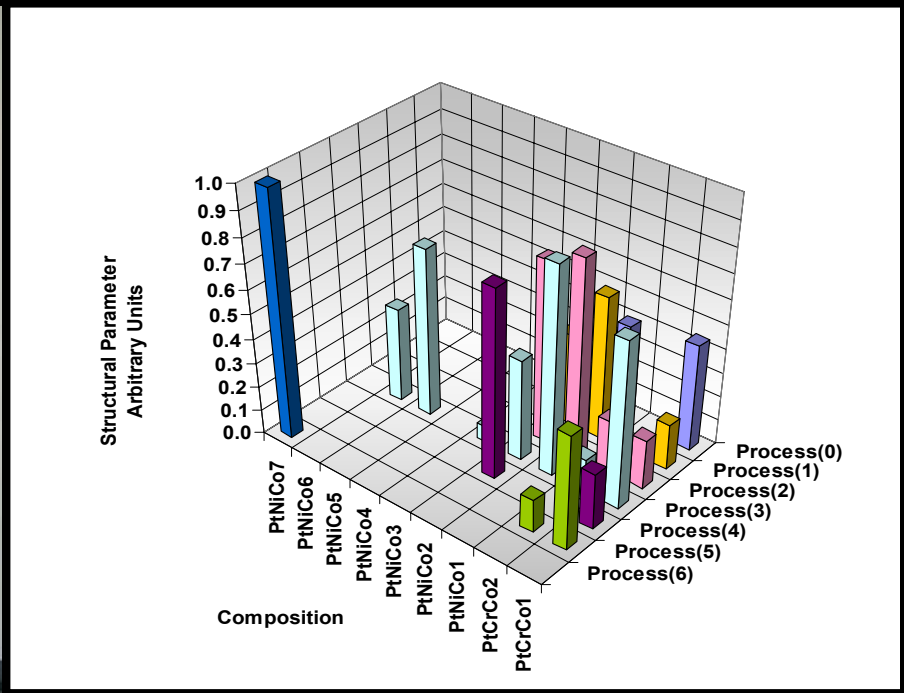
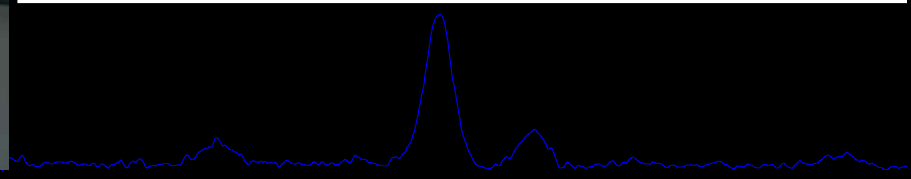




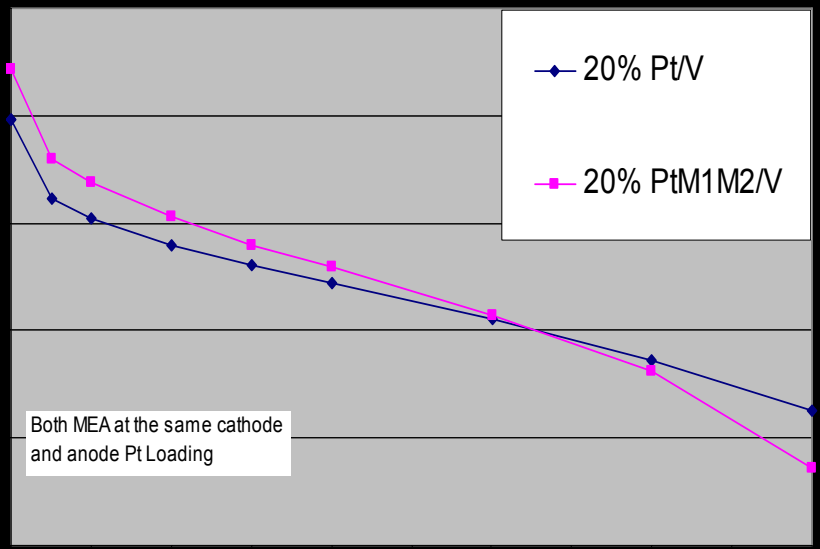
Characterization of Pt-alloy Electrocatalysts

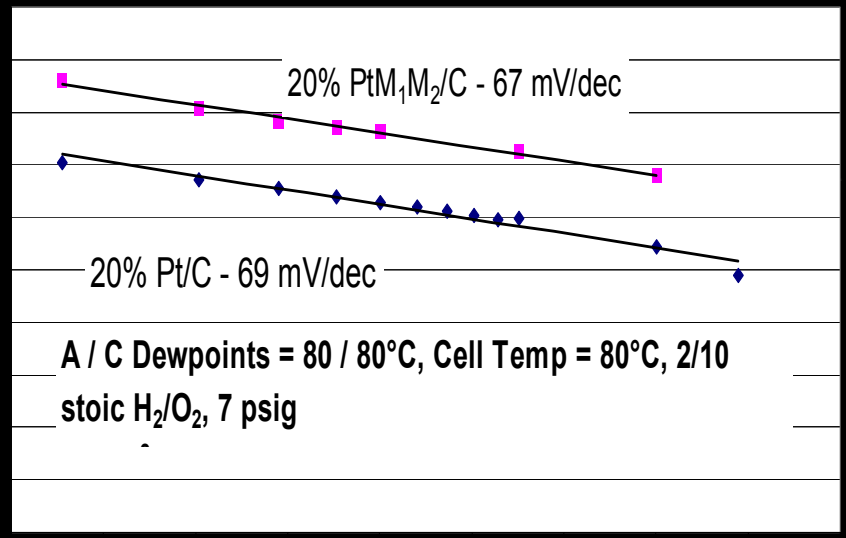




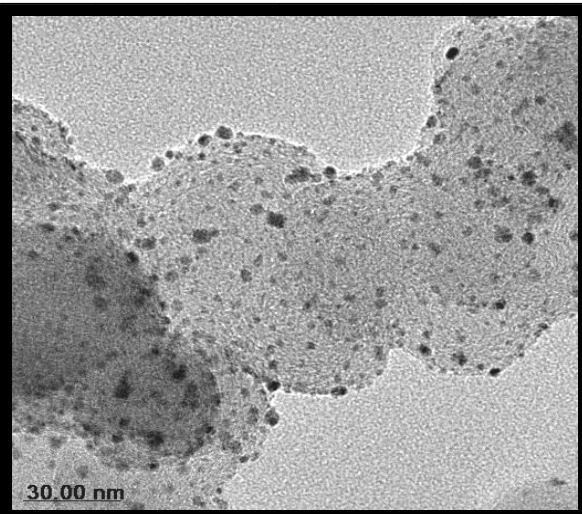
- ***Degree of alloying dependent on spray processing parameters and post-processing conditions***

Characterization of Pt-alloy Electrocatalysts

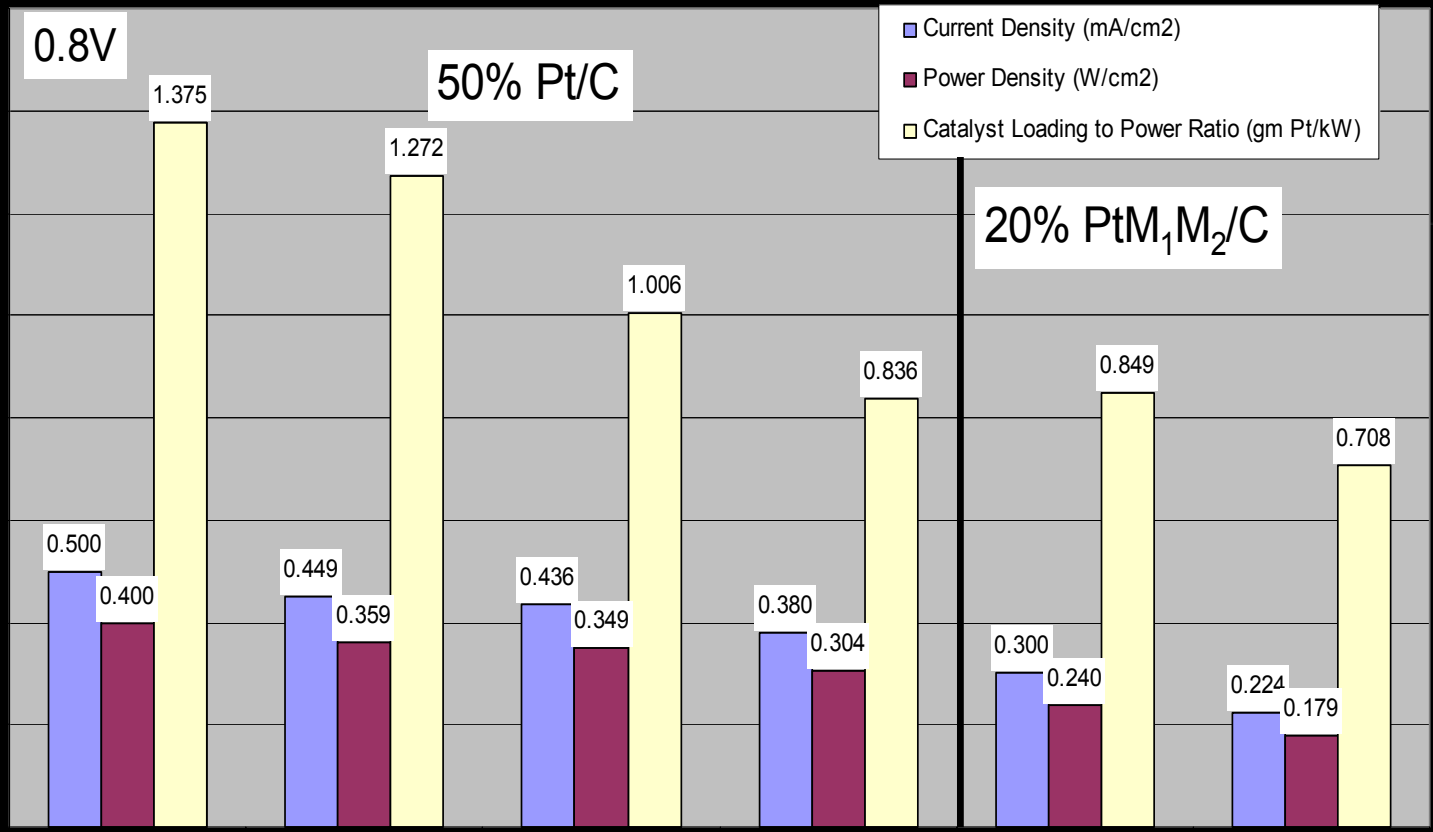




Single 50 cm² MEA Performance
80 C, 1.5H₂/2.5air at 1A/cm²,
100% RH, 30 psig, 15 min/point



MEA Structure Optimization



Single 50 cm^2 MEA Performance Data
80 C, 1.5H_2/2.5air at 1A/cm^2, 100% RH, 30 psig, 15 min/point

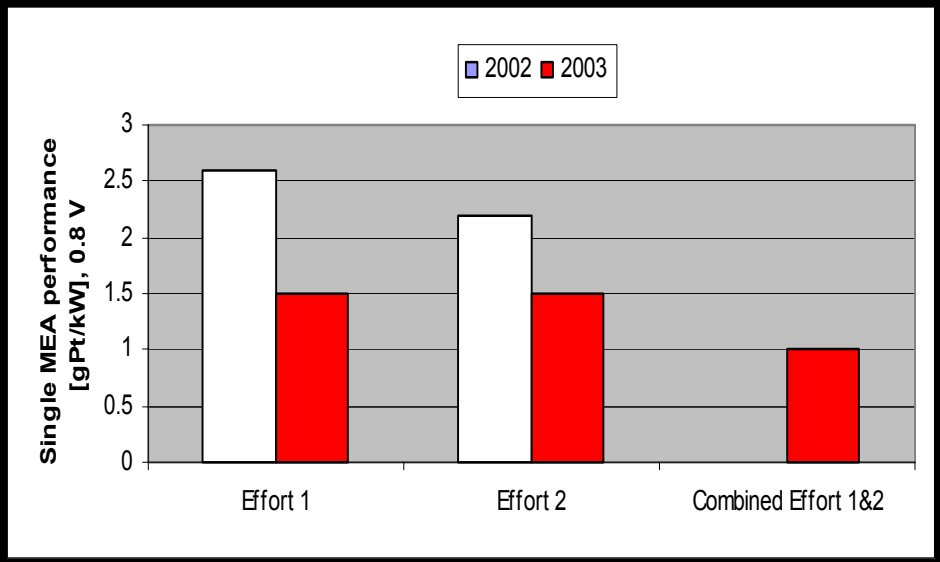
Performance

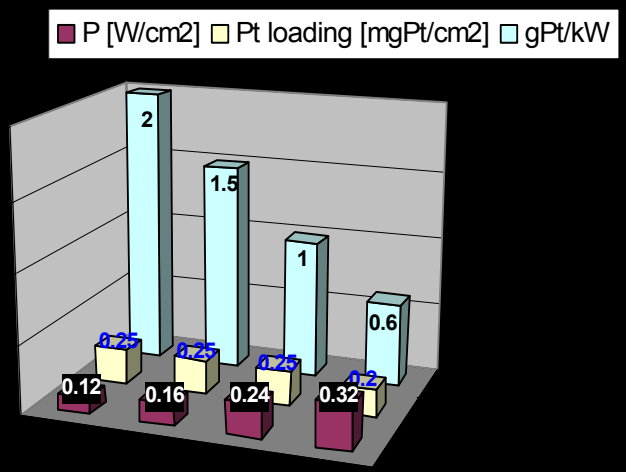
Electrocatalyst Scale Up

Production
1,000's Kg
range

Combinatorial
100 mg range

Combined Effort 1 and Effort 2 Status vs. Performance Targets





- **Effort 1:** Ternary alloy catalyst performance improved from **2.6 gPt/kW to <1.5 gPt/kW**
- **Effort 2:** MEA structure development yields improvement from **2.2 gPt/kW to <1.5 gPt/kW**
- **Combined best alloy catalyst and best MEA structure result in performance of <1 gPt/kW**

Summary and Path Forward

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- Spray-Based Combinatorial Powder Synthesis System Completed
- Successful Synthesis of Alloy Composition Demonstrated and Scaled up
- Screening of Large Number of Compositions in Progress
- Strong Emphasis on Long Term Stability of Electrocatalysts
  - Stability in acidic media
  - Stability to active phase agglomeration
- Rapid testing in MEA configuration
- Testing in Stacks

Acknowledgements

- DOE OTT, Award DE-FC0402AL67620,
- DOE Program Manager: Valri Lightner
- CSMP, DuPont Fuel Cells and CFDRC for cost share funding
- The whole CSMP team and especially: Jenny Plakio, Heath Quiggle, Tomas Wood, Bryan Apodaca, Henry Romero
- DuPont Fuel Cells: JoAnn Schwartz, Lin Wang,Keith Tomey, Richard Okine